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A contribution to the taxonomy of *Lyromma* (*Lyrommataceae*, lichenized *Ascomycota*) with a species key

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Abstract — The paper presents a new concept of conidial-ascosporic relationship in the foliicolous lichenized genus *Lyromma* and a revised key to species determination. *Lyromma coronatum* sp. nov. (Bolivia) is characterized by reduced perithecial appendages composed of clavate hyphae that form a crown around the ostiole. *Lyromma multisetulatum* sp. nov. (Bolivia, Brazil) is characterized by numerous large strongly recurved perithecial appendages composed of individual acicular hyphae. Undescribed ascosporic states for *Lyromma dolicobelum* and *L. palmae* and conidial states for *L. ornatum* and *L. pilosum* are described based on observations of perithecia and pycnidia for the first time in natural conditions. Confirmation of a conidial-ascosporic connection for *L. nectandrae* suggests *L. confusum* as a synonym. *Lyromma dolicobelum*, *L. nectandrae*, and *L. ornatum* are reported as new to Bolivia, and *L. pilosum* as new to Bolivia and Brazil.

Key words —Neotropics, new species, South America

Introduction

This is a new contribution to the foliicolous lichens of Bolivia (Flakus & Lücking 2008) within an inventory aimed to establish knowledge on the diversity of lichens and allied fungi in the country (e.g. Flakus & Wilk 2006, Flakus et al. 2008, Flakus 2009, Knudsen & Flakus 2009, Kukwa & Flakus 2009, Flakus & Kukwa 2012, Flakus et al. 2012, Kukwa et al. 2012).

The foliicolous lichenized genus *Lyromma* Bat. & H. Maia (*Lyrommataceae* Lücking, *Chaetothyriales*), containing six species accepted by Lücking (2008), is characterized by globose to short barrel-shaped perithecia and elongate barrel-shaped pycnidia, sessile on smooth ecorticate thalli of rounded patches formed by symbiotic relationship with *Phycopeltis*. Perithecia are composed of a thin

layer of irregular dark brown hyphae, and persistent or evanescent paraphyses comprise the hamathecium. The bitunicate obclavate to saccate asci (I–, KI–) contain 8 transversely septate fusiform colorless ascospores. Pycnidia (formed by a thin layer of distinctly parallel dark brown hyphae) produce multiseptate filiform colourless macroconidia or non-septate bacilliform microconidia. Mature perithecia and pycnidia both form appendages in the upper part near ostiole, composed of either individual or agglutinated hyphae (Batista & Maia 1965, Cavalcante et al. 1972, Lücking 1992, 2008, Lücking et al. 1998).

Lyromma was established as a monospecific pycnidial genus for *L. nectandrae* (Batista & Maia 1965, Lücking et al. 1998). Perithecia were described originally for *L. nectandrae* (Lücking 1992, Aptroot et al. 1997) and later for *L. ornatum* (Lücking & Kalb 2000). For a long time, *L. nectandrae* was the only species known to produce both perithecia and pycnidia (Lücking 1992, Aptroot et al. 1997). However, a re-examination of the known *Lyromma* material by Lücking (2008) showed that no single collection contained both perithecia and pycnidia on the same thallus. Moreover, specimens assigned to *L. nectandrae* with perithecia were shown to belong to different taxa described later as *L. confusum* and *L. pilosum* (Lücking 2008). Since ascosporic and conidial states were not observed on the same thallus, the perithecial and pycnidial morphotypes had been treated as different species until their taxonomic status could be clarified. Finally, based on the then-available specimens, Lücking (2008) proposed three taxa with perithecia and three with pycnidia.

We have been able to study further fresh collections of foliicolous lichens from Bolivia and Brazil and discovered more and more thalli of the otherwise rare *Lyromma* species. These new findings form the basis of our re-evaluation of the species concept based on conidial-ascosporic relationships.

Material & methods

Morphology and anatomy were examined by using Nikon SMZ800 and a Nikon Eclipse 80i (DIC), as well as Olympus SZX9 and Olympus BX50 (DIC) microscopes. Preparations were studied in water and KOH solution (K), and for ascus structure in Lugol's iodine solution without (I) or with pre-treatment with KOH (K/I). All anatomical measurements were made in water.

Handling the sporocarps required great care to establish exact sizes and numbers of setae. Anatomy, measurements, and number of setae should be examined on sectioned or squash mounts in water under a compound research microscope.

Results

Lyromma coronatum Flakus & Farkas, **sp. nov.** Plate 1a, b

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Differs from other *Lyromma* species by its reduced perithecial appendages composed of numerous individual clavate hyphae that form a regular crown around the ostiole.

Type — Bolivia, Dept. Beni, Prov. Ballivian, near Río Pircayo, 14°18′56″S 67°26′34″W, 190 m, lowland Amazon forest, 4 Dec. 2004, A. Flakus 4315 (**Holotype**, KRAM; **isotype**, LPB).

Etymology — The species is named after its reduced appendages forming a characteristic crown around ostiole.

Thallus foliicolous, epiphyllous, ecorticate, formed by rounded patches, smooth, 0.4–3 mm wide, olive-green; photobiont *Phycopeltis*, cells rectangular, 12–20 × 4–6 µm, arranged in radiate plates; perithecia sessile, globose, 50–100 µm in diam., and 50–80 µm high, pale brown, around ostiole furnished with crown of almost reduced appendages; ostiole apical, 20–35 µm wide; setae dark brown, almost reduced to 5–7(–12) × (4–)5–7 µm, forming a very regular crown around ostiole, composed of numerous individual clavate, apically thickened (apical walls c. 1 µm thick) hyphae (sometimes branched apically); peridium pale brown, 3–5 µm thick, composed of rectangular cells (3–5 µm wide), thick walled (c. 1–1.5 µm thick), arranged irregularly to almost parallel; paraphyses sparse in mature perithecia, simple, c. 1 µm thick; asci bitunicate, 8-spored, 30–50 × 10–15 µm; ascospores fusiform, hyaline, 3-septate, with slight constrictions at septa, upper second cell usually slightly enlarged, 17–20 × 4–5 µm; pycnidia not seen.

Distribution & ecology — The new species is known from two localities in Bolivia, one of which is located in the protected area Reserva Nacional de Vida Silvestre Amazónica Manuripi. It grows on leaves of vascular plants in lowland Amazon forest.

Additional specimens examined — **BOLIVIA. Dept. Pando.** Prov. Manuripi, Reserva Nacional de Vida Silvestre Amazónica Manuripi, Bajada colony near Chive village, near Río Madre de Dios, 12°24′03″S 68°26′45″W, 170 m, 2006, A. Flakus 6018 (herb. Flakus).

Comments — *Lyromma coronatum* is characterized mainly by pale brown perithecia and the presence of reduced perithecial appendages that form a characteristic crown around the ostiole composed of numerous very short clavate hyphae. The species can be confused with the ascosporic state of *L. palmae*, which produces appendages composed of similar clavate hyphae. Therefore, we initially regarded the new species as the juvenile form of *L. palmae* with not fully developed appendages. However, a detailed study showed that *L. coronatum* is mature species with fully developed asci and the largest ascospores yet known in the *Lyromma* (Lücking 2008). Thus, *L. palmae* can be distinguished from the new species by its darker perithecia (especially in the upper part), and the perithecial appendages that are larger [10–30(–40) µm long], erect to horizontal, composed of about 20–60 individual hyphae, and usually grouped in 3–6 brush-shaped appendages (then faintly agglutinated in basal part). The two species also differ in the size of the photobiont cells (12–20 × 4–6 µm in *L. coronatum,* and 10–13 × 5–6 µm in *L. palmae*), ascospores

(17–20 × 4–5 µm in *L. coronatum,* and 14–18 × 3–5 µm in *L. palmae*), and the ostiole width (25–35 µm in *L. coronatum,* and 15–20 µm in *L. palmae*).

Lyromma dolicobelum Cavalc., in Cavalcante et al., Publ. Inst. Micol. Univ. Fed. Pernambuco 647: 39. 1972. PLATE 1C

TYPE — Brazil. Roraima: Mucajaí-Caracaraí, II 1962, de Lima 19682 (URM 37178 – holotype; INPA– isotype).

"*Lyromma nectandrae* var. *dolicobelum*" Bat. & Cavalc., in Bezerra et al., Atas Inst. Micol. Univ. Fed. Pernambuco 5: 386, 389, 397, 409, 421. 1967, nom. nud.

[See Lücking (2008) for a detailed description of pycnidia.]

THALLUS foliicolous, epiphyllous, ecorticate, formed by rounded patches, smooth, 2–8 mm wide, olive-green; PHOTOBIONT *Phycopeltis*, cells rectangular, 10–17 × 4–7 µm, arranged in radiate plates; PERITHECIA sessile, subglobose to globose, 50–80 µm in diam., and 60–80 µm high, dark brown, around ostiole furnished with 2–3(–4) setae; SETAE dark brown to black, tubular, almost horizontal to recurved, 60–200(–300) µm long and 20–30 µm broad in basal part, composed of agglutinated hyphae; PERIDIUM dark brown, lower part slightly paler, 2–4 µm thick, 3–5 µm thick, composed of rectangular cells (2–5 µm wide), thick walled (c. 1–1.5 µm thick), arrangement irregular to almost parallel; PARAPHYSES sparse in mature perithecia, simple, c. 1 µm thick; ASCI bitunicate, 8-spored, 30–35 × 10–15 µm; ASCOSPORES fusiform, hyaline, 3-septate, with slight constrictions at septa, 16–18 × 4–5 µm.

DISTRIBUTION & ECOLOGY — This species, known previously only from lowland Amazon forest in Brazil and lowland rainforest in Mexico (Cavalcante et al. 1972, Lücking et al. 1998, Herrera-Campos et al. 2004, Lücking 2008), is now reported for Bolivia.

SELECTED SPECIMENS EXAMINED — **BOLIVIA. DEPT. PANDO.** PROV. MANURIPI, Reserva Nacional de Vida Silvestre Amazónica Manuripi, Puerto Rico village, 11°06′12″S 67°31′14″W, 191 m, 2006, A. Flakus 6570 (LPB); PROV. FEDERICO ROMAN, near Santa Cruzito colony, 10°43′03″S 65°55′05″W, 149 m, 2006, A. Flakus 7107, 7160, 7111, 7257, 7127 (KRAM, LPB, herb. Flakus).

COMMENTS — *Lyromma dolicobelum* is distinguished from all other *Lyromma* species by the few but very long appendages, up to 200–300(–400) µm long and composed of agglutinated hyphae.

Lyromma multisetulatum Flakus & Farkas, **sp. nov.** PLATE 1D; 2A, J

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Differs from *Lyromma pilosum* by its more numerous, larger, and strongly recurved perithecial appendages.

TYPE — Bolivia, Dept. Santa Cruz, Prov. Guarayos, Reserva Vida Silvestre Rios Blanco y Negro, Plan de Manejo AISU, 15°01′58″S 62°46′36″W, 242 m, lowland Amazon forest, 24 July 2009, A. Flakus 13961 & P. Rodriguez (**Holotype**, KRAM; **isotype**, LPB).

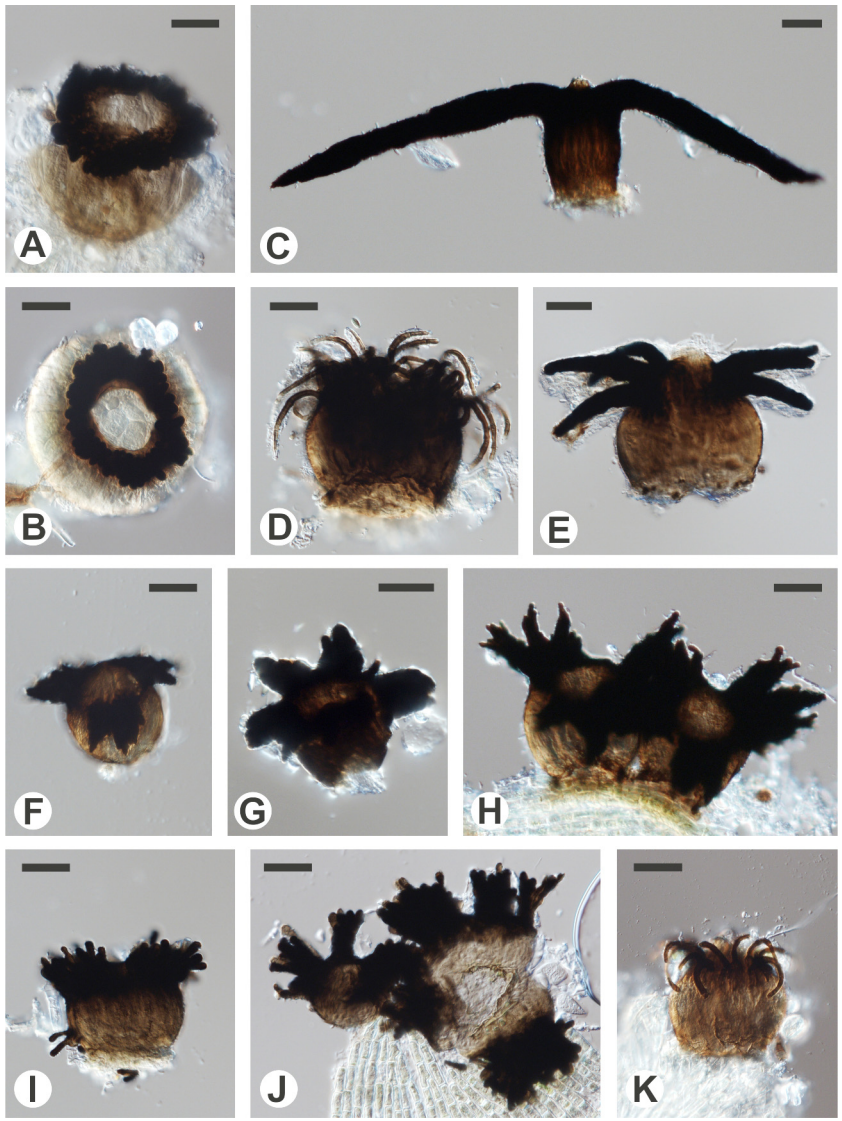

Plate 1. Morphology of perithecial appendages of *Lyromma*. A–B: ***L. coronatum***, reduced, forming a crown around ostiole (holotype). C: ***L. dolicobelum***, tubular, horizontal to recurved, composed of agglutinated hyphae. D: ***L. multisetulatum***, setose, recurved, composed of individual acicular hyphae (holotype). E: ***L. nectandrae***, tubular, horizontal to recurved, composed of agglutinated hyphae. F–H: ***L. ornatum***, triangular to irregularly lobate (H, deeply divided), horizontal, composed of agglutinated hyphae. I–J: ***L. palmae***, setose to brush-shaped, erect, composed of individual clavate hyphae or agglutinated at the base (J, brush-shaped). K: ***L. pilosum***, setose, recurved, composed of individual hyphae. Scale bars = 25 μm.

Etymology — The species is named after its strongly recurved appendages produced in large numbers near the top of perithecia.

Thallus foliicolous, epiphyllous, ecorticate, formed by rounded patches, smooth, 1–2 mm wide, olive-green; photobiont *Phycopeltis*, cells rectangular, 18–22 × 6–8 µm, arranged in radiate plates; perithecia sessile, subglobose to globose, 70–80 µm in diam., and 70–90 µm high, dark brown, around ostiole furnished with (10–)15–30(–40) setae; setae dark brown, septate, strongly recurved, composed of individual hyphae, 30–50(–60) µm long and 3–4 µm broad (2–3 µm broad in apical part); peridium dark brown, lower part slightly paler, 3–4 µm thick, composed of rectangular cells (3–4 µm wide), thick walled (c. 1 µm thick), arrangement irregular to almost parallel; paraphyses sparse in mature perithecia, simple, c. 1 µm thick; asci bitunicate, 8-spored, 30–35 × 10–13 µm; ascospores fusiform, hyaline, 3-septate, with slight constrictions at septa, 14–18 × 4–5 µm; pycnidia elongate, barrel-shaped with tapering top, 100–130 µm high and 80–90 µm wide, dark brown, upper part around ostiole furnished with 15–30 setae; setae dark brown, septate, strongly recurved, composed of individual hyphae, (20–)30–50(–60) µm long and 3–4 µm broad (1–2 µm broad in apical part); conidia (microconidia) bacilliform, non-septate, 2–5 × 0.8–1.2 µm.

Distribution & ecology — The new species is known from the Reserva Vida Silvestre Rios Blanco y Negro, Bolivia and the Private Nature Conservation Reserve founded by Károly Kögl near São Paulo, Brazil. It grows on vascular plant leaves in lowland Amazon forest and Atlantic submontane rainforests.

Additional specimens examined — **BRAZIL. Estado São Paulo.** São Roque, sobre la Lagunita, al Norte de la Laguna Sapucaia, ca 850 m, 1995, A. Borhidi s.n. (VBI).

Comments — *Lyromma multisetulatum* is characterized by its numerous [(10–)15–30(–40)], long [30–50(–60) µm], and strongly recurved perithecial appendages, each composed of an individual hypha. It is the first *Lyromma* species known to produce microconidia. Perithecia of the most similar species, *L. pilosum,* differ in forming less numerous appendages [(5–)10–15] that are less curved and almost twice as short (10–15 µm) (Lücking 2008).

Lyromma nectandrae Bat. & H. Maia, Atas Inst. Micol. Fed. Univ. Pernambuco 2: 360. 1965. Plate 1e

Type — Brazil. Pernambuco: Recife, Dois Irmãos, III 1960, Soares da Silva 13832 (URM 18764 – holotype); Brazil: Amazonas: Manaus, Itacoatiara, VII 1967, Omar 40677 (URM 69375 – epitype, designated by Lücking et al.: 145. 1998).

= *Lyromma confusum* Lücking & Sérus., in Lücking, Fl. Neotrop. Monogr. 103: 187. 2008.

Type — Papua New Guinea, Madang prov. Balek Wildlife Reserve, c. 15 km S of Madang along road to Lae, 5°18′S 145°43′E, c. 20 m, in tropical lowland rainforest, on tree trunk/on shaded limestone cliff (former coral reef), 29 July 1992, E. Sérusiaux 13555-17 (LG – holotype!).

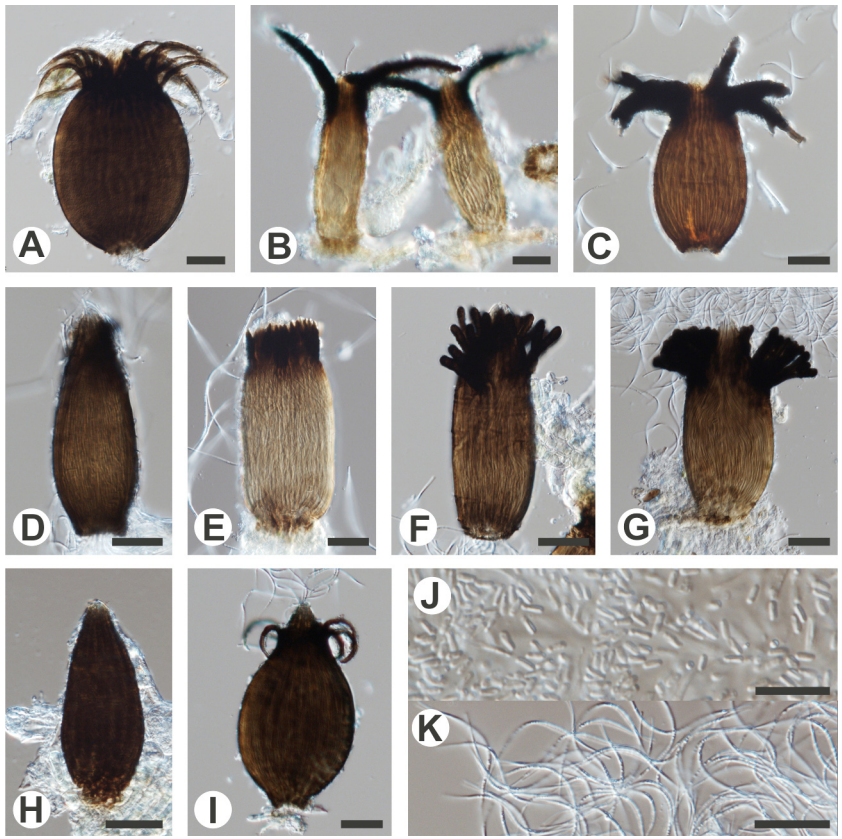

Plate 2. Morphology of pycnidial appendages and anatomy of conidia of *Lyromma*. A: ***L. multisetulatum***, setose, recurved, composed of individual acicular hyphae (holotype). B–C: ***L. ornatum***, tubular (simple to furcate), horizontal to recurved, composed of agglutinated hyphae (B, young pycnidia). D–G: ***L. palmae***, setose, erect, composed of individual clavate hyphae (D, young, glabrous pycnidium). H–I: ***L. pilosum***, setose, recurved, composed of individual acicular hyphae (H, young, glabrous pycnidium). J: ***L. multisetulatum***, short, bacilliform microconidia (holotype). K: ***L. pilosum***, large, filiform macroconidia. Scale bars: A–I, K = 25 µm; J = 10 µm.

"*Lyromma confusum*" Lücking, in Herrera-Campos et al.,
Lichenologist 36: 315. 2004, nom. nud.

[For detailed descriptions see Batista & Maia (1965) and Lücking (2008)].

Distribution & ecology — This pantropical species is rather widespread in the Neotropics, where it is known from Argentina, Brazil, Costa Rica, Ecuador, French Guyana, Mexico, and Panama (Sipman 1997, Ferraro & Lücking 2000, Herrera-Campos et al. 2004, Lücking 2008), and is now also reported from Bolivia, where it was found in lowland rainforests.

Selected specimens examined — **BOLIVIA. Dept. Beni.** Prov. Ballivian, near Pircayo river, 14°18′56″S 67°26′34″W, 190 m, 2004, A. Flakus 4174.1 (LPB). **Dept. Pando**. Prov. Federico Roman, near Santa Cruzito colony, 10°43′03″S 65°55′05″W, 149 m, 2006, A. Flakus 7193.1, 7298 (KRAM, LPB). **Dept. Santa Cruz**, Prov. Guarayos, Reserva Vida Silvestre Rios Blanco y Negro, Virgen de Pilar near Chonta village, 15°38′54″S 62°57′37″W, 229 m, 2009, A. Flakus 13481, 13381.1 & P. Rodriguez (KRAM, LPB); Plan de Manejo AISU, 15°01′58″S 62°46′36″W, 242 m, 2009, A. Flakus 13911 & P. Rodriguez (LPB). **BRAZIL. Estado Tocantins**. Toncinópolis, 3 km al NE de la ciudad, Fazenda de José Borges cerca del Riacho Francisco, 1995, A. Borhidi s.n. (VBI). **Estado Rio de Janeiro**. Serra do Mantiqueira, Parque Nacional de Itatiaia, en el alrededor del Cachueiro Veu da Noiva, ca 1300–1500 m, 1995, A. Borhidi s.n. (VBI). **PAPUA NEW GUINEA. Madang Province.** Pont de la Gogol River, route de Lae à env. 15 km de Madang, 5°20′S 145°43′E, 30 m, 1987, J. Lambinon 87/370 (LG); Ramu valley. Brahman, along road to Bundi, 5°46′S 145°21′E, 200 m, 1992, E. Sérusiaux 14200–2 (LG); Fothills of Finisterre range, along road Madang-Lae, km 39, c. 230 m, 1992, E. Sérusiaux 14303–48 (LG). **Central Province.** N of Brown River, 3 km NE of Hiritano highway, 30–50 m, 1987, J.R. Sloover 87 L 23 (LG). **INDONESIA. Bali.** Gianyar District, Gununk Kawi, 8°28′S 115°18′E, 1991, 500 m, L. Hoffmann 91–115 (LG).

Comments — Although Lücking (2008) considered the perithecial appendages of *Lyromma confusum* morphologically very similar to those on the pycnidia of *L. nectandrae,* he treated the two as separate taxa because there was no proof of a conidial-ascosporic connection. We found thalli bearing pycnidia typical of *L. nectandrae* mixed together with perithecia of *L. confusum* and so regard *L. confusum* as a synonym of *L. nectandrae*.

Mature perithecia of *L. nectandrae* have 3–5, horn-shaped, recurved (rarely horizontal), 30–70 µm long and 10–15(–20) µm broad (at the base) appendages and are sometimes 2–3-furcate at the ends (Lücking 2008). Young undeveloped *L. nectandrae* specimens can be confused with *L. ornatum,* which has short perithecial appendages but which can be distinguished from mature *L. nectandrae* material by the irregularly lobate to triangular, horizontal (rarely slightly recurved), comparatively shorter [15–30(–40) µm long], perithecial appendages (Lücking & Kalb 2000, Lücking 2008).

Likewise, the pycnidia of *L. nectandrae* are morphologically similar to those of *L. ornatum* (shown on Plate 2C) with (2–)3–5 cylindrical to irregular appendages that are 40–60(–100) µm long and 10–15 µm broad (at the base) and may be simple to 2–3-furcate at the ends (Batista & Maia 1965, Lücking 2008).

Lyromma ornatum Lücking, Kalb & Sérus., in Lücking & Kalb, Bot. Jahrb. Syst. 122: 39. 2000. Plate 1F–H; 2B, C

Type — Brasilien. São Paulo, Serra do Mar, Serra do Garrãozinho, zwischen Mogi das Cruzes und Bertioga, in einem primären Regenwald, 23°45′S 46°10′W, 300–600 m, 6.IX.1980, K. Kalb 32601 & G. Plöbst (herb. K. Kalb – holotype!).

[For detailed descriptions of the thallus and perithecia, see Lücking & Kalb (2000) and Lücking (2008)].

Pycnidia elongate barrel-shaped with a tapering top, 100–120 µm high and 35–60 µm in wide, dark brown, upper part around the ostiole furnished with 2–4 setae; setae dark brown to black, recurved, composed of agglutinated hyphae, cylindrical to irregular, simple to 2–4-furcate on the ends, 30–80 µm long and 10–20 µm broad (at the base); conidia (macroconidia) filiform, multiseptate, 50–80 × 0.8–1.2 µm.

Distribution & ecology —This species, rather widespread in the Neotropics, has been reported from Argentina, Brazil, Ecuador, Peru, Mexico, and Surinam (Ferraro & Lücking 2000, Lücking & Kalb 2000, Herrera-Campos et al. 2004, Lücking 2008). These are the first records from Bolivia, where it is known only from lowland Amazon forest.

Selected specimens examined — **BOLIVIA. Dept. Beni.** Prov. Ballivian near Pircayo river, 14°18′56″S 67°26′34″W, 190 m, 2004, A. Flakus 4173 (LPB). **Dept. Pando**. Prov. Manuripi, Reserva Nacional de Vida Silvestre Amazónica Manuripi, Bajada colony near Chive village, 12°24′03″S 68°26′45″W, 170 m, 2006, A. Flakus 6019.1 (LPB); Chive village, 12°23′19″S 68°34′39″W, 157 m, 2006, A. Flakus 6407 (KRAM, LPB); Puerto Rico village, 11°06′12″S 67°31′14″W, 191 m, 2006, A. Flakus 6554, 6565 (KRAM, LPB); Prov. Nicolas Suarez, near Cobija village, 11°02′16″S 68°45′31″W, 191 m, 2006, A. Flakus 6455, 6457 (KRAM, LPB, herb. Flakus); Prov. Madre de Dios, Reserva Nacional de Vida Silvestre Amazónica Manuripi, Puerto Madre de Dios village, 11°30′56″S 67°16′07″W, 153 m, 2006, A. Flakus 6802, 6865 (KRAM, LPB); Prov. Federico Roman, near Santa Cruzito colony, 10°43′03″S 65°55′05″W, 149 m, 2006, A. Flakus 7275 (LPB). **Dept. Santa Cruz.** Prov. Guarayos, Reserva Vida Silvestre Rios Blanco y Negro, Virgen de Pilar near Chonta village, 15°38′54″S 62°57′37″W, 229 m, 2009, A. Flakus 13381, 13382 & P. Rodriguez (KRAM, LPB); Plan de Manejo AISU, 130 km from Ascención de Guarayos village, 15°03′35″S 62°45′20″W, 258 m, 2009, A. Flakus 13841, 13842 & P. Rodriguez (KRAM, LPB, herb. Flakus). **BRAZIL. Estado Tocantins.** Toncinópolis, 3 km al NE de la ciudad, Fazenda de José Borges cerca del Riacho Francisco, 1995, A. Borhidi s.n. (VBI).

Comments — Studies on a wide range of material show that *Lyromma ornatum* exhibits considerable variation in the shape and size of its perithecial appendages. The species forms 3–6 horizontal to (rarely) slightly recurved appendages composed of distinctly agglutinated hyphae, which are triangular to irregularly lobate but sometimes also deeply divided at the apex, 15–30(–40) µm long and 7–15(–20) µm broad (at the base). Morphotypes with strongly incised appendages are externally similar to the perithecia of *L. palmae*. However, *L. palmae* has erect to horizontal appendages, composed of 20–60 clavate hyphae (apically ≤4–7 µm broad), usually grouped into 3–6 brush-shaped appendages (then faintly agglutinated at the base). *Lyromma nectandrae*, another similar species (see above), has much larger recurved perithecial appendages (30–70 µm long) (Lücking 2008).

Only a few poorly developed (probably juvenile) pycnidia were observed on thalli of *L. ornatum* together with perithecia typical for the species. They most closely resemble those of *L. nectandrae* in having recurved simple to

2–4-furcate appendages composed of agglutinated hyphae, but they are less numerous [2–3(–4)] and shorter (30–80 µm long). The relationship between these two species can be clarified only by studying more complete material or by molecular analyses.

Lyromma palmae (Cavalc. & A.A. Silva) Lücking & Sérus., in Lücking et al., Lichenologist 30: 136. 1998. PLATE 11, J; 2D–G

≡ *Anconomyces palmae* Cavalc. & A.A. Silva, in Cavalcante et al., Publ. Inst. Micol. Univ. Fed. Pernambuco 647: 26. 1972.

TYPE — Brazil. Amazonas: Manaus, Manaus, Rodovia AM-1, km 55, Aug 1961, Carvalho 17065 (URM 29109 – holotype; INPA – isotype); Brazil. Maranhão: Zé Doca, IX 1965, Peres 25270 (URM 52420 – epitype, designated by Lücking et al.: 136. 1998).

THALLUS foliicolous, epiphyllous, ecorticate, forming rounded patches, smooth, 0.3–3 mm diam, olive-green; PHOTOBIONT *Phycopeltis*, cells rectangular, 8–21 × 4–7 µm, arranged in radiate plates; PERITHECIA sessile, subglobose to globose, 40–80 µm in diam., and 40–60 µm high, dark brown, around ostiole furnished with 20–60 individual setae or 3–6 brush-shaped appendages; SETAE dark brown, erect to horizontal, composed of about 20–60 individual, clavate hyphae, 10–30(–40) µm long and (3–)4–6(–7) µm broad (at the apex), setose but usually grouped in 3–6 brush-shaped appendages, then faintly agglutinated at the base; PERIDIUM dark brown, lower part slightly paler, 3–4 µm thick, composed of rectangular cells (2–3 µm wide), thick walled (c. 1 µm thick), arrangement irregular to almost parallel; PARAPHYSES sparse in mature perithecia, simple, c. 1 µm thick; ASCI bitunicate, 8-spored, 30–35 × 10–14 µm; ASCOSPORES fusiform, hyaline, 3-septate, with slight constrictions at septa, second cell from above sometimes slightly enlarged, 14–18 × 3–5 µm; PYCNIDIA elongate barrel-shaped with a tapering top, 100–130 µm tall and 40–55 µm wide, dark brown, upper part around the ostiole furnished with 20–25 setae; SETAE dark brown, erect, usually clavate, septate, composed of individual hyphae, (10–)20–30(–40) µm long, 3–4 µm broad in basal part and (3–)4–6(–7) µm broad in apical part; CONIDIA (macroconidia) filiform, multiseptate, 40–100 × 0.8–1.2 µm.

DISTRIBUTION & ECOLOGY — This species is known from Argentina, Bolivia, Brazil, Costa Rica, and Mexico (Cavalcante et al. 1972, Lücking et al. 1998, Ferraro & Lücking 2000, Herrera-Campos et al. 2004, Flakus & Lücking 2008, Lücking 2008). It is found mostly in lowland rainforests, and also in northern Argentinean forests.

SELECTED SPECIMENS EXAMINED — **BOLIVIA. DEPT. BENI.** PROV. BALLIVIAN, Nuevos Reyes colony, 14°13′17″S 67°28′25″W, 190 m, 2004, A. Flakus 3811 (LPB); near Pircayo river, 14°18′56″S 67°26′34″W, 190 m, 2004, A. Flakus 4174.1, 4195.1 (KRAM, LPB). **DEPT. PANDO.** PROV. MANURIPI, Reserva Nacional de Vida Silvestre Amazónica Manuripi, Bajada colony near Chive village, 12°24′03″S 68°26′45″W, 170 m, 2006, A.

Flakus 5989.3 (KRAM); Puerto Madre de Dios village, 11°27′38″S 67°15′56″W, 166 m, 2006, A. Flakus 6662, 7046 (KRAM, LPB). **Dept. Santa Cruz.** Prov. Guarayos, Reserva Vida Silvestre Ríos Blanco y Negro, Virgen de Pilar near Chonta village, 15°38′54″S 62°57′37″W, 229 m, 2009, A. Flakus 13332, 13491 & P. Rodriguez (KRAM, LPB); Plan de Manejo AISU, 130 km from Ascención de Guarayos village, 15°03′35″S 62°45′20″W, 258 m, 2009, A. Flakus 13842.1, 13842.2 & P. Rodriguez (KRAM, LPB); 160 km from Ascención de Guarayos village near Río Negro, 14°58′50″S 62°36′19″W, 242 m, 2009, A. Flakus 14021 & P. Rodriguez (herb. Flakus).

Comments — The perithecia of *L. palmae* are characterized by the erect to horizontal setae composed of 20–60 clavate hyphae grouped usually into 3–6 brush-shaped appendages, 10–30(–40) μm long and (3–)4–7 μm broad at the apex. This distinguishes it from the most similar species, i.e. *L. coronatum*, *L. ornatum* (see also below), and *L. pilosum*.

The structure of the pycnidia and pycnidial appendages of *L. palmae* were variously interpreted before 2008. According to Lücking et al. (1998), the species was characterized by pycnidia with reduced apical setae, compared to those of, for example, *L. nectandrae* or *L. dolicobelum*. In his subsequent monograph, Lücking (2008) described *L. palmae* as having glabrous pycnidia without appendages. However, the original description and illustration (Cavalcante et al. 1972: 26, fig. 5), as well as a detailed study of the epitype by Lücking et al. (1998: 136) established that the species develops small appendages near the pycnidial apex. The rich collections now available show that *L. palmae* is characterized by pycnidia with 20–25 erect usually clavate setae composed of individual hyphae that are (10–)20–30(–40) μm long, 3–4 μm broad at the base, and (3–)4–6(–7) μm broad at the apex (Plate 2 F, G). Pycnidia of *L. palmae* are somewhat reminiscent of those of *L. pilosum* but differ in having acicular, horn-shaped, and strongly recurved appendages (1–3 μm broad at the apex).

Lyromma pilosum Lücking, Fl. Neotrop. Monogr. 103: 187. 2008. Plate 1K; 2H, I, K

Type — Costa Rica. Puntarenas: Monteverde Biological Reserve, 1600–1700 m, Feb 2000, Lücking 00-418 (CR – holotype).

[For a detailed description of the thallus and perithecia, see Lücking (2008).]

Pycnidia elongate barrel-shaped with tapering top, 100–130 μm tall and 40–60 μm in wide, dark brown, upper part around ostiole furnished with 5–10 setae; setae dark brown, acicular, horn-shaped, strongly recurved, septate, composed of individual hyphae, (10–)20–30(–40) μm long, and 4–5 μm broad (2–3 μm broad in apical part); conidia (macroconidia) filiform, multiseptate, 40–70 × 0.8–1.2 μm.

Distribution & ecology — This species was described from Argentina and Costa Rica (Lücking 2008). Here we report it from Bolivia and Brazil for the first time. It grows in northern Argentinean forests, montane forest, lowland Amazon forest, and Atlantic submontane rainforest.

Selected specimens examined — **BOLIVIA. Dept. Pando.** Prov. Manuripi, Reserva Nacional de Vida Silvestre Amazónica Manuripi, Chive village, 12°23′47″S 68°35′28″W, 179 m, 2006, A. Flakus 5900, 5903.2 (KRAM, LPB); Bajada colony near Chive village by Río Madre de Dios, 12°24′03″S 68°26′45″W, 170 m, 2006, A. Flakus 5975, 6019.2 (LPB, herb. Flakus); Prov. Nicolas Suarez, near Cobija village, 11°02′16″S 68°45′31″W, 191 m, 2006, A. Flakus 6440 (LPB); Prov. Madre de Dios, Reserva Nacional de Vida Silvestre Amazónica Manuripi, near Puerto Madre de Dios village, near Río Madre de Manupare, 11°31′37″S 67°17′29″W, 155 m, 2006, A. Flakus 6719 (KRAM). **BRAZIL. Estado São Paulo.** São Roque, cascada sobre la Laguna Sapucaia, ca 800 m 1995, A. Borhidi s.n. (VBI); sobre la Laguna Sapucaia, arriba del camino, ca 850 m, 1995, A. Borhidi s.n. (VBI).

Comments — *Lyromma pilosum* was the first species of the genus described as having short perithecial appendages composed of an individual hypha (Lücking 2008). It is most similar to *L. multisetulatum* and *L. palmae*, which differ in the size, shape, and orientation of the perithecial appendages. For more details, see remarks below those species.

The pycnidia of *L. pilosum* and *L. palmae* have similar appendages, each composed of individual hypha that is 3–5 µm broad across the base. Juvenile pycnidia of both species are smooth (without appendages) and can be distinguished only in the mature stage. Pycnidia of *L. pilosum* have 5–10 setae, which are acicular, strongly recurved, (10–)20–30(–40) µm long, and 2–3 µm broad at the apex. In contrast, those of *L. palmae* produce 20–25 setae, which are erect, usually clavate, (10–)20–30(–40) µm long, and (3–)4–6(–7) µm broad at the apex.

Key to species of *Lyromma* based on ascosporic and conidial states

1a. Sporocarps perithecia, globose to very short barrel-shaped, usually <100 µm high . . .2
1b. Sporocarps pycnidia, elongate barrel-shaped, usually >100 µm high 8

2a (1a). Perithecial appendages (5–)10–30(–60), setose (strongly recurved) to brush-shaped (erect to horizontal), each composed of individual hypha (sometimes faintly agglutinated at the base), (5–)10–30(–40) µm long and 3–5 µm broad at the base) or almost reduced, forming a crown 3
2b. Perithecial appendages 2–6, horn-shaped or triangular to irregularly lobate, horizontal to recurved, composed of agglutinated hyphae (sometimes deeply divided at the apex), 15–200(–300) µm long and 7–30 µm broad (at the base) 6

3a (2a). Perithecial appendages reduced, forming a crown, composed of individual clavate hypha, 5–7(–12) µm long and (4–)5–7 µm broad (at the apex) . . . . . ***L. coronatum***
3b. Perithecial appendages larger, strongly recurved, setose 10–50(–60) µm long or erect to horizontal, composed of 20–60 individual hyphae usually grouped into 3–6 brush-shaped appendages, 10–30(–40) µm long 4

4a (3b). Perithecial appendages erect to horizontal, composed of 20–60 clavate hyphae usually grouped into 3–6 brush-shaped appendages (then faintly agglutinated at the bases), 10–30(–40) µm long and (3–)4–7 µm broad (at the apex) ..... ***L. palmae***

4b. Perithecial appendages (5–)10–30(–40) strongly recurved setae composed of acicular hyphae, 10–50(–60) µm long and 2–3 µm broad (at the apex) 5

5a (4b). Perithecial appendages (5–)10–15 setae, 10–30(–40) µm long ..... ***L. pilosum***

5b. Perithecial appendages (10–)15–30(–40) setae, 30–50(–60) µm long ..... ***L. multisetulatum***

6a (2b). Perithecial appendages 3–6, triangular to irregularly lobate (sometimes deeply multi-furcated on the apex), horizontal to rarely slightly recurved, 15–30(–40) µm long and 7–15(–20) µm broad (at the base) ..... ***L. ornatum***

6b. Perithecial appendages 2–5, cylindrical to irregular, horn-shaped (sometimes 2–3-furcate on the ends), recurved or rarely almost horizontal, 30–200 µm long and 10–25 µm broad (at the base) 7

7a (6b). Perithecial appendages 3–5; 30–70 µm long, simple to 2–3-furcate on the apex. ..... ***L. nectandrae***

7b. Perithecial appendages 2–3(–4); 60–200(–300) µm long ..... ***L. dolicobelum***

8a (1b). Pycnidia glabrous (when young) or with 5–30 appendages composed of individual hyphae, 3–5 µm broad (at the base) 9

8b. Pycnidia with 2–5 appendages composed of agglutinated hyphae, 10–20 µm broad (at the base) 11

9a (8a). Appendages 20–25, clavate, erect to almost vertical, (10–)20–30(–40) µm long and (3–)4–6(–7) µm broad (at the apex) ..... ***L. palmae***

9b. Appendages acicular, horn-shaped, strongly recurved, 1–3 µm broad (at the apex) 10

10a (9b). Appendages 5–10, (10–)20–30(–40) µm long; macroconidia filiform, multiseptate, 40–60 × 0.8–1.2 µm ..... ***L. pilosum***

10b. Appendages 15–30, (20–)30–50(–60) µm long; microconidia bacilliform, non-septate, 2–5 × 0.8–1.2 µm ..... ***L. multisetulatum***

11a (8b). Appendages (2–)3–5, simple to 2–4-furcate on the ends, cylindrical to irregular, 30–60(–100) µm long and 10–20 µm broad (at the base) ..... ***L. nectandrae*** or ***L. ornatum***

11b. Appendages 2(–3), simple, cylindrical, 200–400 µm long and 10–20 µm broad (at the base) ..... ***L. dolicobelum***

Discussion

During the current study, we discovered undescribed ascosporic states for *Lyromma dolicobelum* and *L. palmae* and conidial states for *L. ornatum* and *L. pilosum*. For the first time in these species both perithecia and pycnidia were observed associated on the same thallus under natural conditions. A conidial-

ascosporic connection for *Lyromma nectandrae* suggests that *L. confusum* should be treated as a synonym of that species. Additionally, two new species of the genus, *Lyromma coronatum* and *L. multisetulatum*, were discovered in material from Bolivia and Brazil.

Since all *Lyromma* taxa have very similar thalli, their relationships have been based on the morphology and anatomy of their sporocarps, with the most useful characters provided by the variable appendages produced near the ostiole both in the ascosporic and the conidial states. From our taxonomic revision of additional, recently collected material, we propose a new concept of the conidial-ascosporic relationships in this foliicolous genus. Despite the many differences between perithecia and pycnidia noted by Lücking (2008), our results show similarities between appendage types that connect ascosporic and conidial states for each species.

Our hypothesis on the generic circumscription, which is probably temporary due to the still limited knowledge on this overlooked genus, can be expected to evolve as new collections and/or molecular sequence data becomes available. The size of these organisms (with a mean thallus diameter normally <5 mm, and sporulating structures around 100 µm high) also limits further studies. We hope, however, that our revised key to *Lyromma* species using both perithecial and pycnidial characters will encourage further research into this fascinating foliicolous lichenized genus.

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